Appendix B. Level of Service Rating and Process

Background

The California Department of Forestry and Fire Protection (CDF) is a statewide resource protection agency. It is the largest multipurpose fire protection agency in the United States. CDF is directly responsible for wildland fire protection of over 31 million acres of California's privately owned watershed lands. In addition, the department provides full fire service protection to nearly 11 million acres under reimbursement agreements with local governments. The department responds to over 7,000 wildland vegetation fires on state responsibility areas each year. Approximately 95 percent of these fires are contained at less than 10 acres.

The heart of CDF's fire protection program is an aggressive initial attack firefighting strategy. CDF commands a force of approximately 3,800 full-time fire professionals, foresters, and administrative employees; 1,400 seasonal personnel; 5,500 local government volunteer firefighters; 2,600 Volunteers in Prevention; and 3,800 inmates and wards. All of these people work aggressively to prevent and suppress wildfires.

CDF operates 1,027 fire engines, (338 state-funded engines and 689 local government funded engines), 103 rescue squads, 12 aerial trucks, 58 bulldozer units, 5 mobile communication centers and 11 mobile kitchen units. CDF also funds 82 engines and 12 bulldozers used to protect state responsibility areas in Los Angeles, Orange, Santa Barbara, Ventura, Kern and Marin counties. In addition to its ground attack capability, CDF maintains a significant fleet of aircraft that includes seventeen 800-gallon air tankers, one 3,000-gallon and two 2,000-gallon contract air tankers, 13 air attack planes, and 10 helicopters.

CDF doesn't fight fire alone. The department cooperates fully with federal and local government firefighting agencies and the governor's Office of Emergency Services. This cooperation is formally defined and authorized in interagency agreements with the federal agencies, in the State Master Mutual Aid Agreement, and in local mutual aid agreements. The department advocates and uses the Incident Command System to efficiently manage the diverse resources used in the firefighting effort.

Level of Service Rating

The legislature has charged the Board of Forestry and CDF with delivering a fire protection system that provides an equal level of protection to lands of similar type (PRC 4130). To do this, the department needs an analysis process that will define a level of service rating that can be applied to the wildland areas in California to

compare the level of fire protection beingprovided. The rating should be expressed as the percentage of fires that are successfully attacked. Success is defined as those fires that are controlled before unacceptable damage and costare incurred.

California has a complex fire environment, with multiple climates, diverse topography and many complex vegetation communities. CDF data on assets at risk to damage from wildfire is incomplete. These factors combine to make it very difficult to develop a true performancebased fire protection planning system. CDF has resorted to prescription-based fire protection planning (travel times of firefighting resources to incidents, report times for the detection system, the same acreage goal statewide, etc.) as a way to overcome the complexity of the issues. Prescription-based planning is possible but tends to oversimplify some issues. Prescription standards also make it difficult to integrate the interrelationships of various fire protection programs, such as the value of fuel-reduction programs to reducing the level of fire protection effort required.

The following approximation method is proposed to overcome these shortcomings and allow CDF to proceed with a damage-plus-cost analysis of fire protection performance. This is a relative system, attempting to measure the relative impact of fire on the various assets at risk. At the same time, this process produces a level of service rating (LOS). The rating can be used to describe fire protection services to “civilians.”

The level of service rating (the score of successes in initial attacks) can be used to compare one area of the state with another, recognizing that the assets at risk may be quite different. This gives CDF a powerful tool for setting program priorities and defining the benefits of the programs. The level of service rating also provides a way to integrate the contribution of various program components (fire prevention, fuels management, engineering and suppression) toward the goal of keeping damage and cost within acceptable limits.

The level of service rating used in this plan is expressed as the percentage of incidents where initial attack effort succeeds. Successful initial attack is defined in terms of the amount of resources needed to suppress the fire and of fire intensity. It is that effort which contains the fire within an acceptable level of resource commitment, acceptable suppression cost and minimal damage to assets at risk.

$$\frac{\text{number of successful initial attacks}}{\text{(total number of initial attacks)}}$$

A matrix is used to define and display successful initial attacks in this framework. The matrix axes defines fire sizes and intensities. The body of the matrix contains the fire activity workload for the fire management analysis zone.

The general matrix has five columns for fires of different sizes and three rows for different intensity levels. The actual size classes and intensity levels are defined for regions of similar vegetation. Thedark shaded portion of the matrix indicates fires that would be expected to exceed budget (and some emergency fund) protection.

The lightly shaded portion indicates successful initial attack suppression, fires that are normally contained within allowable suppression cost.

Intensity	Spots	Small	Medium	Large	Exceed model simulation limits
Low					
Medium					
High					

In this matrix, the lightly shaded area represents fires that are successfully attacked and the dark shaded area represents the unsuccessful initial attacks. This designation of successful and unsuccessful matrix cells would remain the same for all fire management analysis zone (FMAZ) matrices.

Average annual fire activity in the FMAZ is entered into the matrix according to intensity and size of the fires. A ranger unit's fire reports are sorted and tallied by size, intensity and FMAZ. Data from 1985-1994 is used to calculate a 10-year average of fire activity. This workload is then used as a calibration measurement for the California Fire Economics Simulator-Initial Attack Model (CFES-IAM). The modeled results, after calibration, are entered into the matrix and used to calculate the current level of service. Modeled results are used so analysts can maintain consistency with results during later analysis of system changes.

For example, suppose one ranger unit's FMAZ modeled workload looked like this:

Intensity	Spots (0 - .25)	Small (.25 - 5)	Medium (5 - 25)	Large (25 - 300)	Exceed model simulation limits (+ 300 acres)
Low	19	5	2	0	0
Medium	18	9	3	1	0
High	16	8	5	3	1

The level of service rating is the proportion of successful initial attacks to total initial attack workload.

$$\frac{\text{number of initial attack successes}}{\text{(total initial attack workload)}}$$

In this example, the annual average fire activity totals 90, with 80 fires in the successful initial attack portion of the matrix. This produces an 89 percent level of service rating (LOS).

$$\frac{\text{number of initial attack successes}}{\text{(total initial attack workload)}} = \frac{80}{90} = 89 \text{ percent LOS}$$

The score of 89 percent would be used to describe the level of service. It could be compared to scores from other fire management analysis zones in various systems for setting priorities.

By the fall of 1998, the LOS procedure will produce a numeric score of the level of wildland fire protection service with the following characteristics:

- The score can be used to compare service levels in similar vegetation areas in California to help identify areas that are not receiving an equal level of service to lands of similar type.
- The score can be used to compare service levels in different vegetation areas in California to help set priorities for prefire management project funding.
- The process can discern which level of government is providing the service.

Additionally, when presented in different formats, the LOS rating can help explain CDF's initial attack fire protection system.

- Scores can be used to compare CDF's abilities from one FMAZ to another.
- The FMAZ can be mapped and colored or shaded to show levels of service.
- Scores can be used to help identify areas needing additionalprefire management program attention.

The contents of the matrices within a ranger unit can be combined graphically to show the composite workload within the unit.

LOS Rating Process

Areas, Maps and Models

The first step is to define regional areas of similar vegetation types in California. These zones are areas within an administrative (ranger) unit that have generally similar fire behavior and fire effects characteristics. The mapping process will use previously planned response areas as the basic mapping unit. This will ease later integration of the fire plan into operational procedures.

The next step is to define a matrix for the appropriate level of service for the regional vegetation zone. The fire size side of the matrix will be defined through interviews with the region's involved fire managers. The fire intensity side will be defined through an analysis of historic weather data for the zone. The LOS matrix is used to define inputs into the CFES model within each ranger unit.

The California Fire Economics Simulator-Initial Attack Model (CFES-IAM) is then used to model a ranger unit's fire workload. The results are used to calculate the current level of service in each fire management analysis zone in the ranger unit. Modeled results are used so analysts can maintain consistency with results during later analysis of system changes.

CFES-IAM also can be used to calculate the level of service by funding source. Ranger unit, regional and state-level maps can be generated depicting the total level of service and the level of service by funding source. The state-funded LOS map would be used to evaluate CDF's ability to provide an equal level of service to lands of similar type without consideration of other available local or federal firefighting resources.

An LOS rating map would be used as an input in defining areas of the state with high value, high hazard, frequent severe fire weather and low service levels. Ratings can be displayed in different formats to explain CDF's initial attack fire protection system.

- The LOS scores can be used to compare CDF's abilities from one area to another.
- The areas can be colored or shaded to show levels of service on a map.
- The LOS scores can be used to help identify those areas that need additional prefire management program attention.

The level of service rating as defined above uses history to validate the modeling system. The modeled system (CFES) includes the efforts of CDF, any other state-level efforts, local government and federal government efforts. As a calibration step, this balances fire growth modeling vs. production function modeling in the simulator.

The local and federal resources can be removed from the CFES model for a "what if" analysis of the state-funded system. The CFES program will "refight" historic fires as if only CDF resources were available. The result will rate the state-funded response capability. This rating can be used to compare state response capabilities in lands of similar type.

As per the Public Resources Code (PRC 4130), the Board of Forestry is to provide *an equal level of protection to lands of similar type*. Key questions are: What is the state-funded level of service? Are the levels equal on lands of similar type? This portion of the process defines a method for addressing that issue.

The Matrix's Fire Intensity Axis

CDF chose to use three intensity levels to provide consistency with operational procedures. The department uses three levels to define the potential fire workload expected on initial attack fires. The levels are an integral part of a complex response system, used to determine the correct amount of resources to dispatch for an initial attack. Staying with three intensity levels will facilitate integrating the strategic plan with tactical operational plans.

Current research indicates that fire intensity is an important element for estimating fire effects. (Many other parameters, such as duration of burning, flame length and consumption, also relate to damage.) The fire intensity axis of the matrix should capture the most important indicator for damage to the area in question.

As a practical matter, measurements of fire intensity are limited. The fire behavior portion of CFES uses the National Fire Danger Rating System modeling process. NFDRS produces four primary fire behavior parameters:

- **Ignition:** This component captures the factors that relate to ease of ignition of the fuel bed; generally, these are fine fuel moisture and temperature. The

ignition component may work as a predictor of fire activity but, once a fire starts, isn't the best indicator for damage.

- **Spread:** This component covers factors — chiefly wind, along with fine fuel moisture — that affect how fast the fire burns. This can be a good indicator of damage in "light fuel" vegetation types like rangeland but not in broad conditions.
- **Energy release:** This is the energy released from the fuel bed as the fire actively burns through it (the smoldering stage doesn't count). It is heavily affected by fuel moisture, especially from living plants and large dead ones; it is not affected by wind speed. Usually a very good indicator of damage in "heavy fuel" vegetation types like forested areas.
- **Burning index:** This combines the energy released and the rate of spread, and is designed to relate well to flame length. The index can be a very good indicator of damage in "medium fuel" vegetation types like woodland areas. It can also work well in brush and chaparral.

Other NFDRS components and indexes incorporate fire workload (human occurrence, lightning occurrence and fire load indexes) and thus cloud the issue a little. The level of service rating process brings in workload later. The appropriate component for describing fire behavior in the vegetation type will be selected by the fire plan analysis team.

Intensity Analysis

Grouping FMAZs by similar vegetation and fuel types will provide more data matches on weather and fire reports for statistical analysis. There is much data to be collected and correlated.

Select appropriate weather stations: State and national fire managers have used the National Fire Danger Rating System (NFDRS) to collect weather data for over 20 years, first through AFFIRMS and now WIMS software programs. The data is stored in the National Fire Weather Data Library, in the National Computer Center, in Kansas City. It has been designed, recorded, formatted and saved specifically for historical analysis. More than 475 historic and active California weather stations are in this data set. Many of them may not have weather records for the 1985-94 analysis period; 118 of them do.

CDF also has data from about 200 remote, automated weather stations. It is formatted as hourly data and is not ready to be processed through the NFDRS historic analysis programs. This formatting can be done on selected stations to fill voids in the NFDRS weather station data set, but it will take some time.

Calculate fire danger indexes: These indexes can be calculated given the weather data for the FMAZ, the fuel type, slope class, climate and herbaceous vegetation type. The danger rating processor produces a data file of daily fire danger indexes. These indexes can then be linked to the fires that occurred in the area on each day.

Collect fire activity data: Fire activity data for 1985-94 is available for most zones. It covers the incident number, report date and time, arrival date and time, containment date and time, cause, size and location. The location information is based on public land survey data (section, township, range information). The public land survey can be converted to latitude and longitude with an acceptable level of accuracy (center of section); that allows a geographic information system to link fire reports to the appropriate fire management analysis zone.

Collect fire cost data: California's CALSTARS accounting database system has millions of spending records that can be tied to the originating incident and grouped by category. These cost totals can then be related to incident records in the fire activity database.

Merge fire report data with fire danger indexes: There are two ways to link the weather and fire reports. Both linkages will need to be performed for different portions of analysis.

- The data can be linked by weather day. Each record in the data set is a day with weather readings and fire intensity indexes. Fire business is summarized and linked as a yes/no condition. Typical fire business queries are: Did a fire occur on this day? Yes/No. Did a large fire occur? Yes/No. Was some level of expenditure exceeded? Yes/No. This linkage can be used to establish the predictive quality of the index and to set operational decision points. It also can be used to validate the fuel model and weather station selection. A further discussion of this analysis is part of the section describing the intensity axis of the matrix.
- The data can be linked by fire report. The fire intensity index for the day is attached to the fire report record. The same intensity level would be used many times if there were multiple fires on a day. This linkage will provide for the analysis of historic fire activity for the CFES-IAM model.

Compare indexes with fire business: The next step is to define the appropriate intensity level groups — low, medium and high fire intensity. The analysis effort will aim at finding the index, fuel model and/or weather station that best discriminates the types of fire business. Fire business is correlated with the intensity rating as:

- Low — little to no fire larger than the "spot size" in this index range
- Medium — some fire activity but no (or little) history of large or major fires in this index range
- High — history of large fires in this index range

Break points in the intensity level group can be determined by plotting the cumulative frequency distribution curves for all days, fire days, medium-size fire days and large fire days. Fire day definitions are:

- All days — any day with fire weather readings, regardless of fire business
- Fire day — a day with a fire, regardless of size

- Medium-size fire day — a day with a fire larger than “spot” size
- Large fire day — a day with a fire in the “large” or “major” size class

The break points can be found by plotting the distributions and finding the index level where medium-size fire days begin to show up and where large and major fire days begin to show up.

Combine intensity analysis: The intensity analysis will be done at the FMAZ level. The next step is to compare the intensity break points between similar FMAZs and calibrate them so that a single set of break points can be used for the similar FMAZs. This step will allow comparison of level of service ratings among similar FMAZs.

The Matrix’s Fire Size Axis

The fire size classes along the horizontal axis of the matrix reflect the general cost of fighting the fires. They also indicate the general impact on suppression organizations by the extent of resources they tie up and how long the resources are used. These impacts should be similar between fire management analysis zones of the same fuel type but can vary among zones of different fuel types.

Impacts on the initial attack suppression organization are an important element in planning. The matrix allows for a general grouping of fires along the horizontal axis in three size classes representing minimal resource commitment, extended time commitments and major resource commitment.

Small fires (up to a quarter acre or so) are those that have to be extinguished but don’t require a significant resource commitment. This size class includes fires that don’t spread, are suppressed by local citizens, or are otherwise not a problem.

The middle size classes define the small to medium fires that are modeled in the CFES-IAM initial attack simulator. These classes are used to reflect changes in initial attack strategy and use of tactical resources that affect the suppression system.

The last size class indicates the point at which the CFES-IAM initial attack model breaks down, where continuous fuel, weather and slope factors exceed the basic modeling assumptions for those components. This size can vary among FMAZs, subject to regional conditions.

Another important use of the size class breakdown is to provide categories of fires for assessing damage to assets at risk. One common definition of the matrix within similar FMAZs will allow different assets to be combined into a composite matrix and the matrices to be compared from one administrative unit to the next.

Defining Size Classes

Representatives from the field units responsible for fire protection in the FMAZs should be brought together for a structured interview session to define the acreage break points. Interview team members should represent each unit in question and

include a mix of unit chiefs, operations officers, battalion chiefs, administrative officers, air attack officers and others knowledgeable in firefighting in the unit.

The interview team would review the FMAZs in question by examining photographs, maps and fire history data. The unit representative would be asked a series of questions:

- What acreage would account for most of the "non-serious" initial attack fires?
- What acreage accounts for routine initial attack with a short duration impact on initial attack drawdown?
- What acreage represents an upper limit of initial attack and the beginning point for extended drawdown, verging into extended attack?
- What acreage would describe the point where modeling assumptions of continuous slope, fuel and weather no longer are valid?

Team members would answer these questions individually without discussion. The answers would be tabulated and the team, as a group, would discuss them and agree on an acceptable single answer for each question for each FMAZ.

Defining the System Failure Threshold

System success is defined as fires that are managed without either adversely affecting the initial attack system's ability to respond to other incidents or expending significant unallocated resources (emergency fund). CDF's budget structure generally provides that initial attack activities be funded out of an allocated budget. The emergency fund exists to pay for managing wildland fires that escape initial attack. Consequently, fiscal data should show an acreage threshold that indicates significant impacts on the emergency fund.

The field team will evaluate the failure threshold by comparing the emergency fund costs by incident acreage and intensity level to establish the acreage threshold for system failures. The threshold can be defined as the point where significant e-fund expenditures begin. This will be reflected in the acreage side of the level of service rating matrix.

Multiple Major Incident Capability

CDF's wildland fire protection system is based on a strategic concept of initial attack success. Initial attack failures are not only costly, but they also drain suppression resources from readiness and increase the possibility of more initial attack failures. Sufficient resources must be available to meet the workload demands of initial attack failures, the so-called "major fires." The ability to staff and equip major incidents and still retain some initial attack effectiveness is called "depth of resources." As a concept, depth of resources includes all suppression capabilities, from engines and people to financial flexibility, needed for incident management.

A depth of resources analysis is contained in the 1985 Fire Plan, Section 7270. The fire plan field team should review and refresh this analysis. Future generations of the fire plan may be able to refine this methodology.

The Fire Plan Field Team

A field team will be assembled to visit the ranger units; explain the planning process; review and validate prior field work on defining fire management analysis zones, representative fire locations, resource travel times, production rates, etc.; conduct acreage interviews; and otherwise assemble the information needed to complete the fire plan. The team will update field fire planning software and data files as necessary, and will train unit CFES coordinators on the latest version of CFES, other planning software and the fire plan framework and methodology. The team will also visit administrative units to complete those tasks.

A variety of roles and talents will be needed. The team should be led by a SFR IV or CDF administrator-level employee. Members should include people knowledgeable in fuels modeling, vegetation typing, firefighting strategies and tactics, local government and federal resources, statistical analysis, the CFES-IAM software program, and the fire plan framework and process.

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